The University of Michigan • Office of Research Administration
Ann Arbor, Michigan

06343-6-P

N66-14290
(ACCESSION NUMBER)
5
(PAGES)
CR 68981
(NASA CR OR TMX OR AD NUMBER)
1
(THRU)
(CODE)
05
(CATEGORY)

FACILITY FORM 602

November 5, 1965

GPO PRICE $ ______

CFSTI PRICE(S) $ ______

Hard copy (HC) 1.00

Microfiche (MF) .50

Office of Grants and Research Contracts
Code SC
Office of Space Sciences and Applications
National Aeronautics and Space Administration
Washington, D. C. 20546

Subject: Letter Progress Report of Work under Contract NASr-54(06) for the Period 1 June 1965 to 31 August 1965

Gentlemen:

This status report covers work during the period from 1 June 1965 to 31 August 1965 under Contract NASr-54(06), Man-Machine Performance Measurements. By the end of this period approximately 47% of the budgeted funds for the first and second year have been expended.

Work is continuing on conduct and analysis of experimental studies of human performance characteristics in manual control tasks and development of facilities and techniques for manual control systems simulation and for analysis of human performance data.

1. EXPERIMENTAL STUDIES

Operator Performance in Three-State Relay Control Systems

A second experiment (65-4) following upon an earlier study (65-1) which examined the distribution of response times following pulse responses with and without display blanking has been completed. The rationale for using the distribution of pauses following brief pulse responses as a measure of feedback processing time in a three-state relay control system as employed in Experiment 65-1 is described in the progress report dated June 10, 1965 covering work during the period from 1 December 1964 to 28 February 1965. In brief, if an operator makes a short, preprogrammed pulse response, then it is proposed that he must use the time following this pulse to evaluate the effectiveness of the response just made. In Experiment 65-1 the role of visual information in determining the distribution of response times following pulses was explored by briefly withholding visual information, that is, blanking the display for a brief period of time following each pulse. It was found that, for one of the four subjects, this distribution of responses was systematically delayed by an amount corresponding to the delay of the visual information. For three other subjects performance of the task was sufficiently good that few pulses occurred and reliable data on these distributions could not be obtained.

In Experiment 65-4 further examination of this display blanking methodology has been explored. It was hypothesized that the time necessary to process visual feedback ought to be influenced by the extent of signal predictability or coherence in the stream of signals being evaluated. To test this idea the display blanking technique was again employed under two conditions. The first condition was an exact replication of several of the previous display blanking conditions but employed four subjects who had not previously practiced the relay-control task. The second condition was identical to the first except that whenever the display was blanked a random increment in target position was introduced. Thus, after blanking, the target reappeared in a position which was essentially unrelated to the conditions prior to blanking, but with the original velocity. The data analysis has confirmed the earlier finding of a relationship between the duration of display blanking and the distribution of response times following pulses and blanking. However, the manipulation reducing signal predictability was shown to have little effect on these response-time distributions. It appeared that the display blanking operation itself reduces the signal predictability to the extent that further attempts to manipulate predictability do not further lengthen the processing time.

Operator Performance With Predictable Input Signals

Data analysis and compilation are continuing in Experiment 65-2, the parametric study of sine-wave tracking. The major findings of this study to date are given below:

1. After long periods of practice tracking sine waves with no external system dynamics (32 hours) performance with a compensatory display approaches quite closely that produced by a pursuit display. This finding tends to confirm the "successive organization of perception" model of tracking performance proposed by McRuer and Krendel.

2. By the end of extended practice the effect of varying the spring constant in a relatively undamped controller can be reflected in the disproportionate improvement in the integrated error performance at input frequencies believed to correspond to the resonance of the arm - controller combination.

3. For sine-wave input frequencies of .5 cps or below power spectral analysis of the velocity error signal reveals a broad peak of power centered at 1.25 cps and uncorrelated with the input signal frequency. This broad peak of signal power appears early in training and remains essentially unchanged throughout long periods of practice.

4. At frequencies higher than 1.5 cps, the operator's capacity for generating a sine wave and attempting to synchronize it with the input signal in amplitude and phase is reflected in a relatively narrow band of power centered on the input frequency.

In order to explore further the role of visual inputs in creating the broad peak of power uncorrelated with the input signal reported in item 3, a second sine-wave tracking study (65-5) has been initiated. In a pursuit tracking task the operator is provided with a target which presents the input signal position as a function of time and a cursor which describes the position of the system output as a function of time. In this study only the cursor was displayed. No information about the instantaneous position of the input signal was provided. Instead, the subject was shown the amplitude limits of the input signal represented by fixed vertical lines on the face of the CRT. He was given information about input signal frequency by a sequence of clicks alternating between the two ears in such a way that a click occurred whenever the input signal had reached the corresponding amplitude peak. In this way all of the required information for generating sine waves was presented but no information was given which would permit him to track the input signal point for point in time. It is of interest to compare performance in this display mode with performance in the equivalent pursuit and compensatory tasks explored in Experiment 65-2. At high input frequencies this display technique may be as effective as complete visual information. Further it is of interest to examine the effect of this display mode on error-velocity power spectra to determine whether the broad peak in power uncorrelated with the input signal can be attributed to the opportunity to track point for point in time. Experimental testing has begun for this study.

Data collection has been completed in the study described in the June 10, 1965 progress report which examines the ability to learn to reproduce a precisely-specified movement pattern (Experiment 65-3). Data analysis is underway.

2. DEVELOPMENT OF DATA ANALYSIS AND SIMULATION TECHNIQUES

Power Spectral Analysis

For the power spectral analysis of the Experiment 65-2 an analog computer was utilized. The data were re manually, converted to punched cards and normalization, sorting ging, and preliminary data plots were obtained from the Unive . of Michigan's IBM 7090 system. In the interest of improved analysi eed, efficiency and flexibility, this same basic technique is being implemented on a small scale digital-analog system which has been made available on a limited leased-time basis by a project in the University's Meteorology Department. The system will accept real-time or tape-recorded time histories, automatically compute power spectra and transfer these data to digital magnetic tape for IBM 7090 sorting and averaging. It will also provide a real time CRT display of the computed power spectra. This system is planned for analysis of Experiment 65-5 and subsequent work.

Relay-Control Experiment-Programming System

The apparatus used for the two- and three-state relay control tasks has been redesigned and rebuilt to improve flexibility and reliability.

Predictive Display Development

A new task has been initiated on the development and testing of analog mechanizations of predictive display concepts. In the initial stages this work will focus on the development of appropriate mechanizations of fast-time modeling and display systems which meet the desired accuracy requirements within the constraints of analog systems. It is anticipated that this will lead to the implementation of a specific display concept and then provide the opportunity for human performance evaluation of some relatively basic predictive display variables such as prediction span, frequency of up-dating and fast-time simulation fidelity requirements.

Simulation Mechanization

During this reporting period L. E. Fogarty joined the project on a half-time basis. Dr. Fogarty will be concerned mainly with problems of importance for the development of improved simulation technology, including the computer implementation of flight mechanics equations.

Work has been started on two important simulation problems:

1. Computer methods of generating arbitary functions of several variables.

2. An improved method of solving the orbital flight equations.

The first subject is of great importance for simulating the motion of vehicles in the atmosphere. Aerodynamic coefficients commonly are functions of Mach number and vehicle attitude. These functions must be stored in the simulator computer, and frequently use up a large portion of the computer capacity. Series expansion methods offer a means of reducing required storage capacity by a substantial amount.

A report on the subject of function generation was presented at the Midwestern Simulation Council Meeting on September 27, 1965. A paper is in preparation.

An investigation of an improved method of solving orbital flight equations is underway. This work is aimed at extending the method reported by Fogarty and Howe at the Liege Conference on Computation in Aeronautics in 1963. It is hoped that a method can be devised for constraining computer solution of the orbital flight equations to agree with the method of variation of parameters. If this can be accomplished, a substantial gain in computation efficiency over Cowell's or Encke's methods should be realized. The latter two methods are widely used--for example, Encke's method is used in the on board Apollo Guidance Computer.

3. RELATED ACTIVITIES

In July Drs. Fogarty, Howe, and Pew visited Mr. Winblade in Washington to discuss plans for program expansion and in August Mr. Winblade visited project facilities in Ann Arbor.

Dr. Pew represented the project at a one day symposium sponsored by NASA Electronics Research Center, Cambridge, Massachusetts on August 27, 1965.

Personnel

During this reporting period the following personnel have charged time to the subject contract.

	Fraction of Time
R. M. Howe	.10
L. E. Fogarty	.50
R. W. Pew	.75
J. Duffendack	1.00
J. Frait	1.00
R. Gilson	1.00
J. Herzog	1.00
L. Kiplinger	1.00
R. Rapley	.50
M. Rash	.10
M. Robb	.50
R. Zauel	.25

Mr. John Warner is participating in the work of the program with NASA fellowship support.

Sincerely yours,

Robert M. Howe

Robert M. Howe
Information and Control
Engineering Program
Department of Aerospace
Engineering

Richard W. Pew

Richard W. Pew
Human Performance Center
Department of Psychology

Co-Principal Investigators

RWP/mr